

A NEW SPECIES OF BIOLUMINESCENT EARTHWORM FROM NORTH
QUEENSLAND BELONGING TO THE SUBGENUS *DIPLOTREMA*
(OLIGOCHAETA: MEGASCOLECIDAE)

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ABSTRACT

A new species of the Acanthodriline earthworm genus *Microscolex* (*Diplorema*) from the Townsville district of north Queensland is described and figured. The species exhibits alternation of nephropore position, a condition elsewhere within the Acanthodrilinae approached only by members of the endemic New Zealand Neodrilacea. This mutually-shared character is more likely to represent a convergence rather than real phyletic affinity. The new species was found to exude bioluminescent coelomic fluid when agitated, a phenomenon tenuously linking it to the North American genus *Diplocardia*, at least one species of which is known to exhibit a similar reaction.

The endemic Australian subgenus *Diplorema* is known to occupy a range extending from a southeasterly limit near Narrabri, New South Wales (Dyne 1978), through southern Queensland to Cape York Peninsula, and across to the Northern Territory (Jamieson and Dyne 1976), with an isolated record from SW Australia. The new species described in the present study adds a further link to the discontinuous distribution of *Diplorema* species which follows the Queensland coastline.

Populations of worms were found to be restricted to open, comparatively dry, grassy areas, often in the surrounds of semi-perennial creeks (the Townsville region is itself considered to lie in an arid corridor). Such habitat 'preferences' are shared by a large number of *Diplorema* species, possibly indicative of a predominantly geophagous, rather than phytophagous, feeding strategy.

The observation of marked bioluminescent activity in the coelomic fluid of live individuals prompted a detailed systematic study of the species prior to an investigation into the biochemical system involved.

The following abbreviations are used in text and figures:

AM	Australian Museum
BM	British Museum
♀	Female pore
GD	Author's collection

l	Length
♂	Male pore
pr.p	Prostatic porophore
QM	Queensland Museum
s	number of segments
sem.gr	seminal groove
sp.amp	spermathecal ampulla
sp.d	spermathecal duct
sp.div	spermathecal diverticulum
sp.p	spermathecal pore
w	width
U	total circumference

SYSTEMATICS

Genus *Microscolex* Rosa, 1887

Subgenus *Diplorema* Spencer, 1900 Emend.

Diplorema heteropora sp. nov.
(Figs. 1A-D, Table 1, Plate 1)

MATERIAL EXAMINED

HOLOTYPE: Queensland Museum G8890, 147° 02'E, 19° 30'S, Palm Creek, approx. 33 km south of Townsville, under bladey grass in sandy soil, about 30 meters up the creek bank, coll. G. Dyne, 10 Feb 1975.

PARATYPES: QM G8932, AM W6634-5, BM 1978.1.16., same data as holotype; QM G8892-3, AM W6636, BM 1978.1.17, 146° 55'E, 19° 36'S, 7 km E of

Woodstock, on road to Giru, approx. 40 km south of Townsville, in moist to saturated sandy loam under grass and open eucalypts, coll. W. Nash, 13 Mar 1977; QM G8891, 8894, AM W6637, GD 1977.1-2, 146° 49'E, 19° 17'S, 100 m from ring road, James Cook University, Townsville, towards Mt Stuart, in moist sandy soil, coll. W. Nash, 20 Mar 1977; GD 1978.3, BM 1978.1.18, AM W6638, QM G8895-6, 0.5 km from ring road, towards Mt Stuart, in moist black clayey soil.

DESCRIPTION

183+, 154 mm; w (midclitellar) 5.9, 7.8 mm; s 134, 264 (Holotype (posterior amputee), Paratype QM G8932). Form circular in cross-section throughout; pigmentless buff in alcohol, clitellum purplish-grey. Prostomium pro-lobous, peristomium much furrowed. First dorsal pore 18/19; setae 8 per segment, commencing in II in regularly spaced longitudinal rows throughout; setae *a* and *b* of XVII and XIX modified as penial setae, those of VIII and IX as genital setae, setae *a* and *b* absent from XVIII.

Nephropores visible externally only on the clitellum, alternating between *c*-lines (sometimes a little shifted towards *b*) and a position far lateral of *d*, near the mid-dorsal line; the pores discharging in the intersegmental furrows. Clitellum annular, encompassing, with the exception of the male field, segments XIII-XIX,

slightly encroaching into XX. Setae and intersegmental furrows only partially obscured on the clitellum. Male pores small points lateral of *b* in XVIII, close to 17/18, located slightly lateral of a pair of well-defined seminal grooves. Prostatic porophores 2 pairs, the trans-segmental pairs conjoined by the somewhat sinuous seminal grooves. The central region of the male field (demarcated by the intersegments 17/18, 19/20, and the seminal grooves) is depressed, with the raised porophore mounds projecting ventrally into it; there is a similar ventralwards extension of the male field margin in mid-XVIII. Female pores are conspicuous as a pair of small slits immediately anterior of *a*, in XIV. Spermathecal pores 2 pairs, inconspicuous, situated in 7/8, 8/9, obscured by segmental overlap. A broadly diffuse tumescence associated with the genital setae is discernible in the ventral seta surrounds of segments VIII and IX.

Septation: 5/6-9/10 strongly muscularized and thickened, 7/8 the thickest; 10/11 moderately strengthened, 11/12 slightly so. Dorsal blood vessel single; last hearts in XIII. Supra-oesophageal vessel present, traceable only in X-XV; only those commissurals in X-XIII may be regarded as heart-like, with connectives to both the dorsal and supra-oesophageal vessels; the

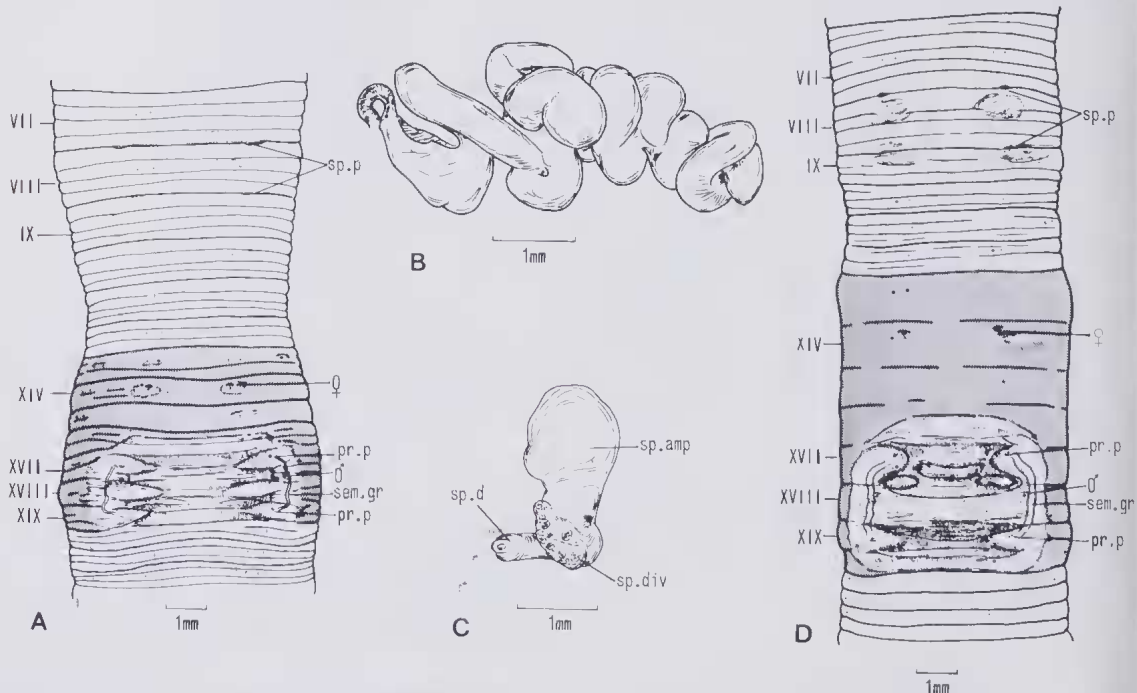


FIG. 1: *Diplostrema heteropora*: A, Genital field of Holotype; B, Dorsal aspect of right prostate gland of Holotype; C, Right IX spermatheca of Holotype; D, Genital field of QM G8892.

remainder are dorso-ventral only, decreasing in size anteriorly. Gizzard large, firm and muscular, in V; oesophagus narrow, internally rugose, lacking pouching or calciferous glands; intestine commences in XIX, typhlosole developed as a low ridge after XXIX, intestinal walls somewhat thickened and folded.

Simple stomate holonephridia present throughout, with conspicuous ducts alternating regularly in the position of exit to the exterior; alternation internally appears to be from *cd* to far dorsal of *d*, though the duct apparently travels a short distance within the parietes. Nephridial bladders absent. A large pair of tufted nephridia present in IV, with a well-defined composite duct passing anteriorly. In III, the duct bifurcates, sending one branch dorsally, the other continuing along the ventrolateral body wall; the fate of the two respective ducts was not definitely determinable, though in all probability, they terminate enteronephrically in the buccal cavity. Holandric; 2 pairs of medium-large iridescent sperm funnels present in X and XI, and 2 pairs of racemose seminal vesicles with distinct component loculi in IX and XII. Two pairs of tubular, highly coiled, yet compact, prostate glands in XVII and XIX, each with a muscular, medium length duct passing to the exterior. Vasa deferentia not demonstrable in H., but in QM G8892 (Woodstock Popn.) they are obvious as a pair of iridescent tubes winding on the body wall on each side, turning dorso-laterally to skirt the internally glandular manifestation of the male field, becoming slightly more swollen, finally entering the parietes, unfused, in XVIII. Two pairs of conjoined (*a* and *b*) penial seta follicles are associated with the prostatic ducts in

XVII and XIX, each containing a number of small, curved, reddish setae, in varying stages of growth; the shaft of mature setae are more or less regularly ornamented with series of very shallow circumferentially orientated indentations; length of mature seta = 1.87 mm; midshaft diameter = 32.5 μ m (mean of 2).

Ovaries, composed of fan-shaped egg-strings, together with plicate funnels in XIII. Spermathecae 2 subequal pairs in VII and IX, each composed of a sacciform ampulla, with sessile diverticulum at the junction of ampulla and duct, the diverticulum internally partitioned into numerous iridescent intramural sperm chambers; the duct long and slightly sinuous; ratio, length spermatheca: length of duct = 3.0. Two pairs of genital seta follicles are associated with the spermathecal ducts; these follicles are themselves embedded in discrete lobulated glandular tissue. The setae are, but for the proximal and distal extremities, ornamented with a regularly arranged pattern of distally sloping concavities, giving the seta a serrated appearance; the tip is sometimes further elaborated by a pair of longitudinally directed grooves. Length of mature seta = 1.02 mm; midshaft diameter = 44.2 μ m (mean of 2).

PARATYPIC VARIATION: Small interpopulation differences in the configuration of the genital field were observed: one of the specimens from the type locality, AM W6634 and particularly some Woodstock paratypes, e.g. QM G8892, possessed three additional tumescences within the male field; one elongate marking intermediate between the anterior pair of porophores, the remaining two

TABLE 1: INTERSETAL DISTANCES IN *DIPLO TREMA HETEROPORA* EXPRESSED AS PERCENTAGES OF THE PERIPHERY

	aa	ab	bc	cd	dd	dc	cb	ba	U (in mm)
HOLOTYPE	10.90	1.96	8.42	1.67	66.3	1.67	7.07	2.06	14.93
QM G8932	12.98	1.70	8.37	1.41	62.9	1.37	9.68	1.61	19.64
AM W6635	11.91	1.56	9.23	1.73	63.7	1.71	8.58	1.54	18.25
QM G8892	11.29	1.60	8.90	1.66	64.9	1.47	8.59	1.60	19.09
QM G8893	12.66	1.64	9.6	1.22	62.8	1.36	9.55	1.21	16.85
AM W6636	10.70	1.65	9.24	1.22	66.3	1.10	8.33	1.49	19.68
BM 1978.1.11	12.17	1.75	8.28	1.48	64.3	1.33	8.96	1.70	18.70
\bar{x}	11.80	1.69	8.86	1.48	64.5	1.43	8.68	1.60	
S_x	0.87	0.13	0.52	0.21	1.45	0.21	0.87	0.26	
S_x	0.33	0.05	0.20	0.08	0.55	0.08	0.33	0.10	
Townsville Population									
QM G8894	13.95	1.91	9.08	1.64	61.5	1.56	8.5	1.89	14.45
AM W6637	11.72	1.47	8.96	1.37	63.2	1.59	10.20	1.49	15.88
GD 1977.1	13.86	1.63	10.15	1.35	60.7	1.40	9.27	1.60	15.77
\bar{x}	13.18	1.67	9.40	1.45	61.8	1.52	9.32	1.66	

elliptical, immediately below the porophores; in some specimens, there are additional markings in 19/20 and/or 20/21. Unlike the type, in most specimens, the median ventralwards projections of the male field are produced as to form a single raised median ridge. Considerable variation also exists as to the degree of development of the swelling associated with the genital setae in VIII and IX.

Internals: In QM G8892-3 and AM W6636, the supra-oesophageal vessel is more highly developed than the condition described for the Holotype, extending from VIII-XIV; the origin of the intestine may vary from XIX(H.) to XVII (as in QM G8932) or XVIII (AM W6634, QM G8892-3); muscular thickening observed in the Holotype was not found developed to the same degree in any other specimens examined.

REMARKS

Nephropore alteration distinguishes *D. heteropora* from the remainder of the genus. The configuration of the genital field is also unique. The occurrence of the first dorsal pore in the clitellar region is not elsewhere recorded for *Diploptrema*, though an even further posterior position is described for *D. eremia* (Spencer 1896), in which the pores commence in the postclitellar region (confirmed in Jamieson and Dyne 1976).

BIOLUMINESCENCE OBSERVATIONS

Live worms from Townsville were found to exude copious bioluminescent coelomic fluid on electrical stimulation (using a 50 volt magneto) or prolonged mechanical agitation. Addition of dilute peroxide greatly enhanced the emission of light, producing a 'flash-peak', and thereafter, rapidly waning activity. The emitted light appeared yellow-green to the dark-adapted eye.

Similar activity was recently recorded by Jamieson (1977) for a species of *Digaster*, *D. keasti*, though this species did not exhibit spontaneous luminosity. The stimulation, by peroxide, of increased activity, particularly in the spontaneously luminescent *Diploptrema heteropora*, suggests the existence of a peroxidase-type bioluminescence system, as demonstrated for the North American acanthodrilid *Diplocardia longa* (Bellisario et al. 1972). In this species, the luciferin substrate has been found to be a relatively simple aldehyde (Ohtsuka et al. 1976).

Jamieson (1977) discusses the adaptive significance of bioluminescence in earthworms. Nash (pers. comm.) has found that the Townsville

worms do not demonstrate luminosity throughout the entire year. Such seasonality could be correlated to a breeding cycle, in which case the bioluminescence may be a functional component of a mate recognition system.

DISCUSSION

Within the Acanthodrilinae, nephropore alternation as seen in *Diploptrema heteropora* has previously been confined to the Neodrilacea, an apparently homogeneous aggregate of four genera restricted to New Zealand. The type genus of the group, *Maoridrilus*, was originally partitioned from *Acanthodrilus* on the basis of alternating nephropore series by Michaelsen in 1899, and later united with *Neodrilus* and *Plagiochaeta* in a group termed the 'Maoridrilacea' (Michaelsen 1928). Stephenson (1930), in reviewing the acanthodrilid genera, reasserted the integrity of the group as his 'Sectio Neodrilacea' a name retained by Lee (1959), at the hierarchical level of Tribe, when revising the New Zealand earthworm fauna, and incorporating a further new genus, *Neochaeta*.

In *Maoridrilus* the nephropores alternate between the dorsal and ventral setal couples, whereas in *D. heteropora*, the alternation is between the dorsal setal couples and a position yet further dorsal by a distance exceeding *bc*. The vast majority of members of the Neodrilacea possess nephridial bladders, often differing in shape according to the position of the nephridial body; such structures are totally lacking in *D. heteropora* or any other known Australian acanthodrilid.

It is probable that the evolution of the condition seen in *D. heteropora* has been a completely independent event, and indicates no direct affinity with the New Zealand forms other than, perhaps, common retention of genetic pre-adaptation inherent in primitive, mutually-shared Pan-Gondwanan ancestors.

In overall morphology (e.g. arrangement of the male terminalia, possession of penial and genital setae, the number and general appearance of the spermathecae) *D. heteropora* is an unremarkable *Diploptrema* species. Though the fixation of nephropore alternation amounts to a morphological apomorphy (phyletic advance), with respect to the numerically dominant single-series acanthodrilids, it is difficult to envisage a satisfactory adaptive advantage deriving from such a configuration. In forms with large nephridial bladders (e.g. *Maoridrilus*), such a condition may represent the most parsimonious

solution to a 'packing' problem; no such adaptive pressures apply, however, in the avesculate *D. heteropora*, unless one accepts the remote possibility that ancestral forms of this species originally possessed bladders, and have since lost these. A further hypothesis might be that in the event of the excretory fluid acting as a locomotory lubricant, an alternating nephropore arrangement would provide a more satisfactory distribution of the fluid. Alternatively, the condition may have arisen simply as a pleiotrophic effect of genes encoding for other characters, which are, themselves, under considerable selective pressure.

The affinities of *Diplotrema* with the extra-Australian *Diplocardia* are discussed in Jamieson and Dyne (1976); the mutual possession of bioluminescence systems with at least partially compatible cross-reactivity (Wampler, pers. comm.) may be interpreted as further evidence of a definite relationship between these two genera.

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PLATE I

- FIG. 1: Midshaft region of penial seta from right XIX follicle;
FIG. 2: Genital seta from right VIII follicle of Holotype;
FIG. 3: Detail of midshaft region of 2;
FIG. 4: Genital seta from right VIII follicle of QM G8892.

